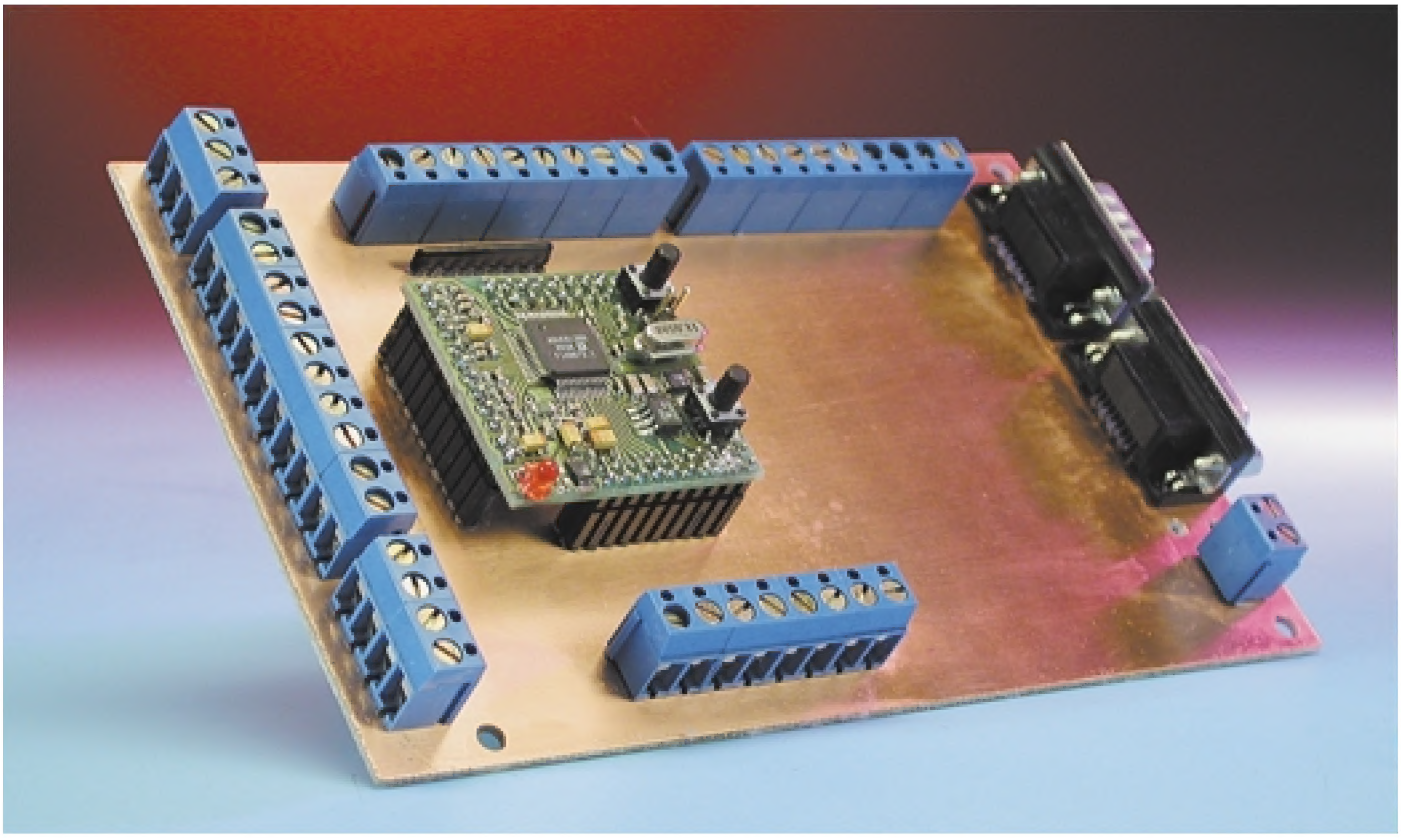
ISAC (2)

part 2: the ISAC Cube

By Prof. Dr. B. vom Berg, P. Groppe and M. Müller-Aulmann

This cube is the basic module of the Elektor Electronics ISAC (Intelligent Sensor/Actuator Controller) project and includes a compact core system using an Analog Devices ADuC812 MicroConverter, which was described in last month's introductory instalment. The tiny SMD circuit board can be used like a large IC in an application circuit or in the prototype board presented here.

The ISAC cube is a flexible and modular microcontroller system for both simple and complex applications. Producing a plug-in circuit board allows easy upgrades to existing applications by simply exchanging the cube for a newer one, if and when Analog Devices bring out new devices in the MicroConverter series with enhanced facilities.



As can be seen from a glance at the picture of the circuit board of the ISAC cube, only a very few components are required to construct a minimal ADuC812-based system. The biggest problem is fitting the MicroConverter device itself, with its many pins; this problem can be solved by obtaining the SMD circuit board with components already fitted.

Circuit diagram of the ISAC cube

The ADuC812 circuit shown in **Figure 1** is more or less as recommended in the data sheet [1]. A standard 8051 microcontroller-style crystal circuit using the familiar 11.0592 MHz crystal frequency allows (among other things) easy generation of baud rates for the serial communications interface. The analogue inputs are fitted with low-pass filters with a cutoff frequency of around 300 kHz. Bypass capacitors are fitted according to Analog Devices' recommendations.

All other important system connections are brought out to multiway pinheaders X1, X2, X3 and X4, to allow the ISAC cube to be connected to the outside world. It is however worth noting that all the external connections are **unprotected**: the ADuC812 can be damaged by excessive voltages or short-circuits on the analogue or digital

Table 1

Characteristics of the ADM707 reset circuit:

- Two separate reset outputs providing an active-low and an active-high reset signal
- Generation of power-on reset
- Manual reset possible by simply connecting a push-button
- Additional input (PFI) to monitor any desired system voltage, such as low-battery indication in battery-powered applications, with corresponding alarm output PFO
- Low quiescent current consumption: 190 µA.
- Complete data sheet available for download via the Analog Devices homepage [2]

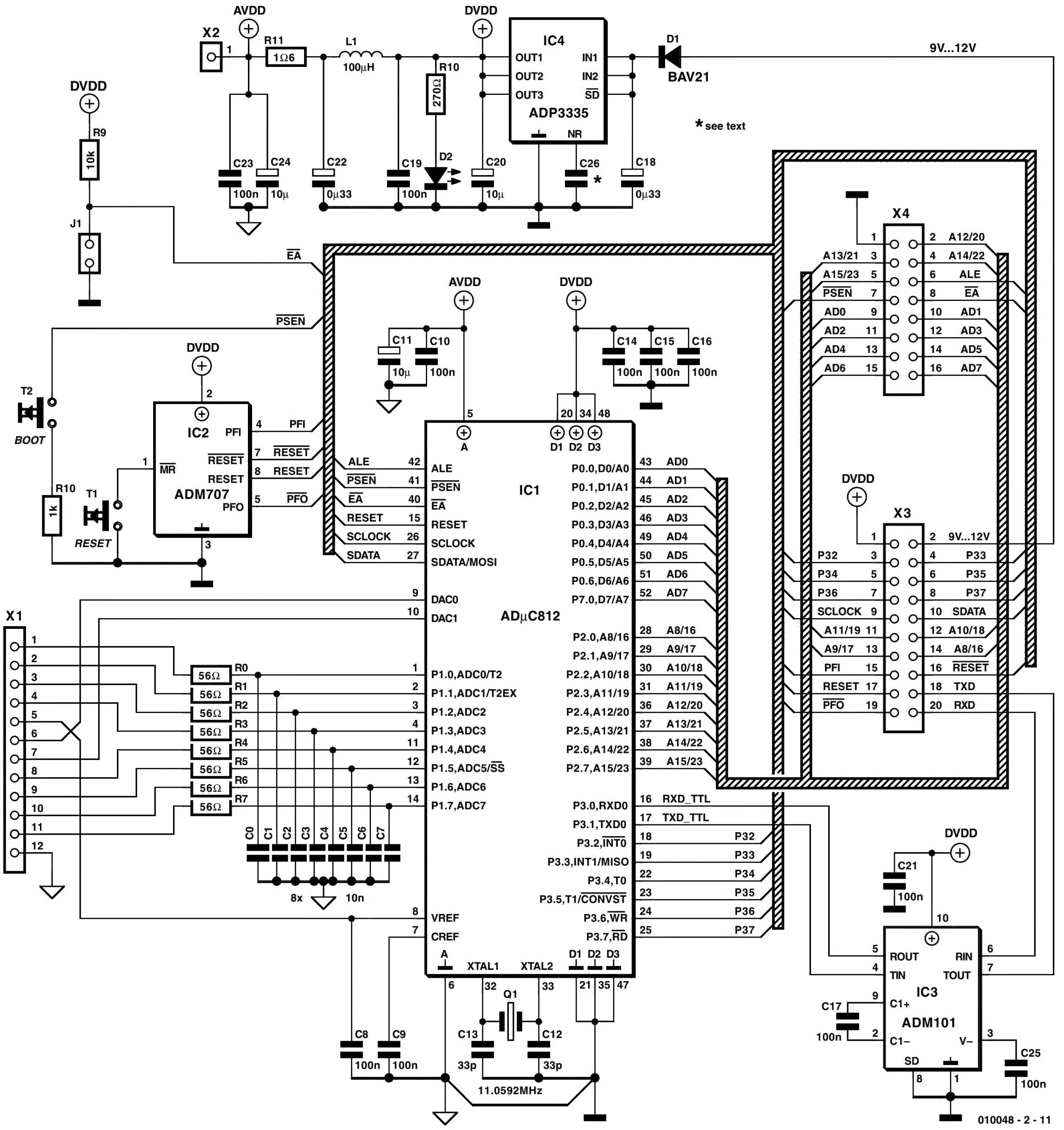


Figure 1. Circuit diagram of the ISAC cube.

COMPONENTS LIST
(ISAC Cube)

(case shapes in brackets)

Resistors:
R11 = 1Ω6 (SMD 1206)
R0-R7 = 56Ω (SMD 0603)
R10 = 270Ω (SMD 0603)
R8 = 1kΩ (SMD 0603)
R9 = 10kΩ (SMD 0603)

Capacitors:
C12,C13 = 33pF (SMD 0603)
C0-C7 = 10nF (SMD 0603)
C8,C9,C10,C14,C15,C16,C19,C23 = 100nF (SMD 0603)
C26 = not fitted
C17,C21,C25 = 100nF (SMD 1206)
C18,C22 = 330nF (SMD 1206)
C11,C20,C24 = 10µF (SMD 1206)

Inductor:
L1 = 100µH (SMD 1206)

Semiconductors:
IC1 = ADµC812 (LPQF-52)
IC2 = ADM707 (SOIC-8)
IC3 = ADM101E (µSOIC-1)
IC4 = ADP3335 (MSOP8)
D1 = BAV21 0.25 A (lead pitch 5mm)
D2 = LED, red, 3mm (lead pitch 2.5mm)

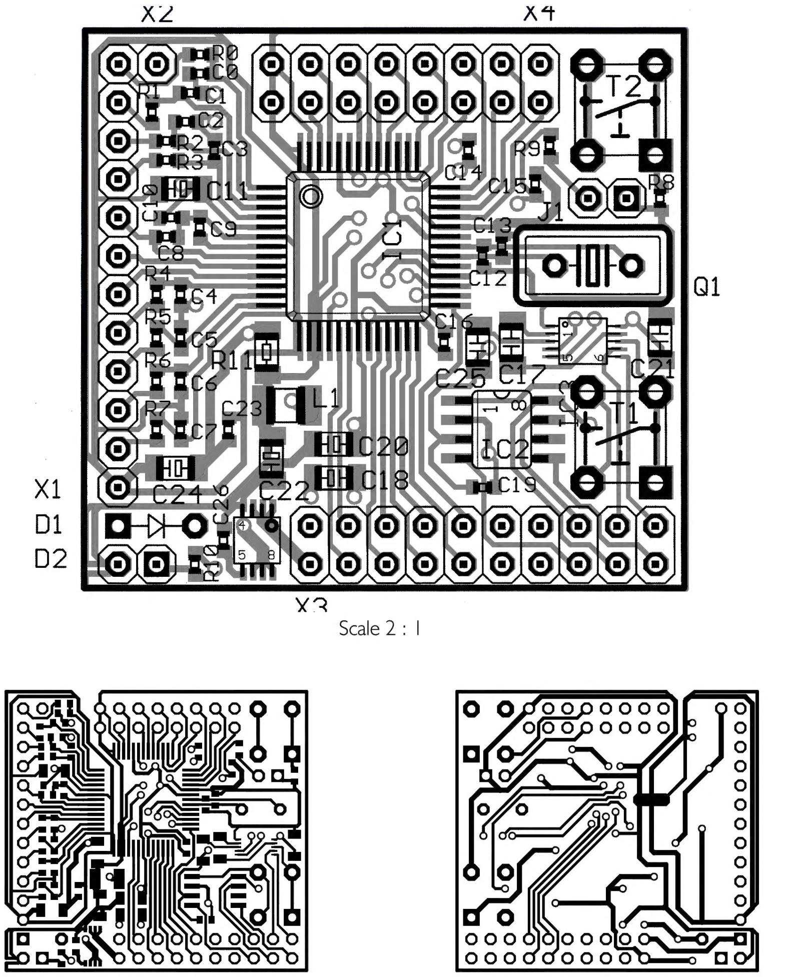
Miscellaneous:
Q1 = 11.0592MHz quartz crystal (HC-49/U)
T1, T2 = PCB mount pushbutton, make contact, 6x6mm
X1, X2, J1 = 15-way SIL pinheader, 2.5mm lead pitch
X3, X4 = 36- way double-row pinheader, 2.5mm lead pitch

port pins. If this is to be prevented by protection circuitry, this must be provided in the external application circuit.

The reset circuit is built using IC2, whose important characteristics are summarised in **Table 1**. The ADuC812 is automatically reset when power is applied or when button T1 is pressed.

IC3, an ADM101E, is responsible for level shifting in the serial interface (for communication with the development PC) from TTL levels to RS232 levels and vice versa. The device is a single-channel level shifter which simply requires the connection of three external capacitors. The full data sheet for this IC can be found via the home page of Analog Devices [2].

The power supply for the cube is provided in the usual fashion by an ADP3335 (IC4),



Scale 2 : 1

Scale 1 : 1

Scale 1 : 1

Figure 2. The SMD circuit board is available ready built and tested from the authors.

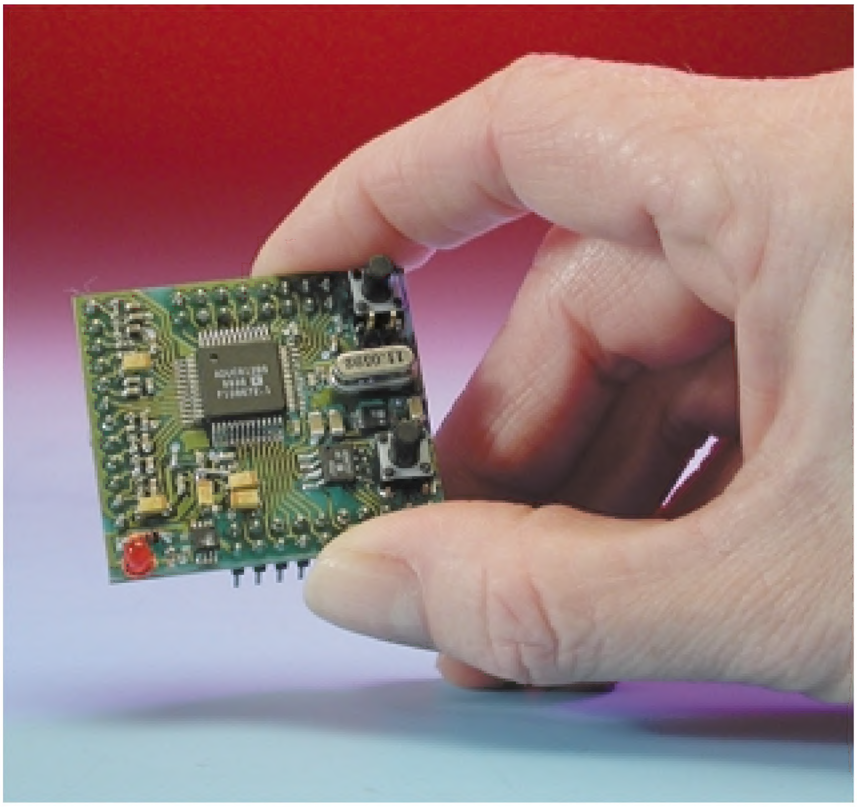


Table 2

Connector pinout of the ISAC cube:

X1	
X1.1	ADC0
X1.2	ADC1
X1.3	ADC2
X1.4	ADC3
X1.5	VREF
X1.6	DAC0
X1.7	DAC1
X1.8	ADC4
X1.9	ADC5
X1.10	ADC6
X1.11	ADC7
X1.12	AGND

X3			
X3.1	DV_{DD}	9V...12V	X3.2
X3.3	P32	P33	X3.4
X3.5	P34	P35	X3.6
X3.7	P36	P37	X3.8
X3.9	SCLOCK	SDATA	X3.10
X3.11	A11/19	A10/18	X3.12
X3.13	A9/17	A8/16	X3.14
X3.15	PFI	RESET\	X3.16
X3.17	RESET	TXD	X3.18
X3.19	PFO\	RXD	X3.20

X4			
X4.1	GND	A12/20	X4.2
X4.3	A13/21	A14/22	X4.4
X4.5	A15/23	ALE	X4.6
X4.7	PSEN\	EA\	X4.8
X4.9	AD0	AD1	X4.10
X4.11	AD2	AD3	X4.12
X4.13	AD4	AD5	X4.14
X4.15	AD6	AD7	X4.16

X2	
X2.1	AV_{DD}

after which a rather extravagant further smoothing circuit is required: the ADuC812 incorporates both a 12-bit A/D converter and a 12-bit D/A converter, and these two high resolution converters make stringent demands on their supply voltage (AV_{DD} und AGND). The digital supply DV_{DD} is provided directly by the ADP3335, and this supply is passed through a special filtering and decoupling circuit (C19, L1, C22, R11, C23 and C24) to provide the AV_{DD}/AGND analogue supply for the ADuC812.

Further, the two grounds (analogue ground AGND and digital ground DGND) must be suitably connected to prevent interference. Design guidance for PCB layout of the power supply network is provided in the 'ADuC812 User Manual: Hardware Design Guide' available for free download over the Internet from Analog Devices [2].

It is worth noting that the ADP3335 voltage regulator is of the 'low dropout' variety, and that at the maximum load of 500 mA an input voltage of only 200 mV above the output is required to provide the components of the ISAC cube with a supply accurate to ±0.9 %. This allows the use of the ISAC cube in battery-powered applications with efficient use of the battery's capacity.

The pinout of the headers on the ISAC cube is shown in **Table 2**.

The current consumption of the cube is around 40 mA (with a 9 V supply and LED D2 connected).

Construction of the ISAC cube

Even for the experienced constructor, building the ISAC cube is not an easy job. Surface mount connection and packaging technology continues to progress, ICs get smaller and smaller and their pins get closer and closer together. Without specialised SMD handling tools or access to a fully fitted-out SMD soldering station assembling the ISAC cube circuit board shown in **Figure 2** is not practical.

To make this pioneering project practical, the authors have decided to offer ready-assembled and tested cubes to interested readers, so that the SMD daughter board can be used as a ready-made module in the same way as a large, powerful IC would usually be used in an application circuit. The cube's pins are set at the standard 2.54 mm (0.1 inch) pitch.

The ready-built cubes are fitted with a pre-programmed ADuC812, so that an initial functional test can easily be carried out. For this purpose a simple prototyping board has been developed with a socket for the cube. **Figure 3** shows the board with ISAC cube fitted. The circuit diagram is shown in **Figure 4**, and the layout and component mounting plan are shown in **Figure 5**. With this simple circuit board, elementary programming experiments and applications can be realised. A more powerful motherboard is planned for future projects.

Set-up and test

To set up your ISAC cube and carry out an initial test, you require only a 9 V power supply and a PC (with a terminal program) connected to the cube or to the prototyping board as shown in **Figure 6**. First measure the current consumption, which should not exceed 40 mA.

On pressing the reset button a welcome

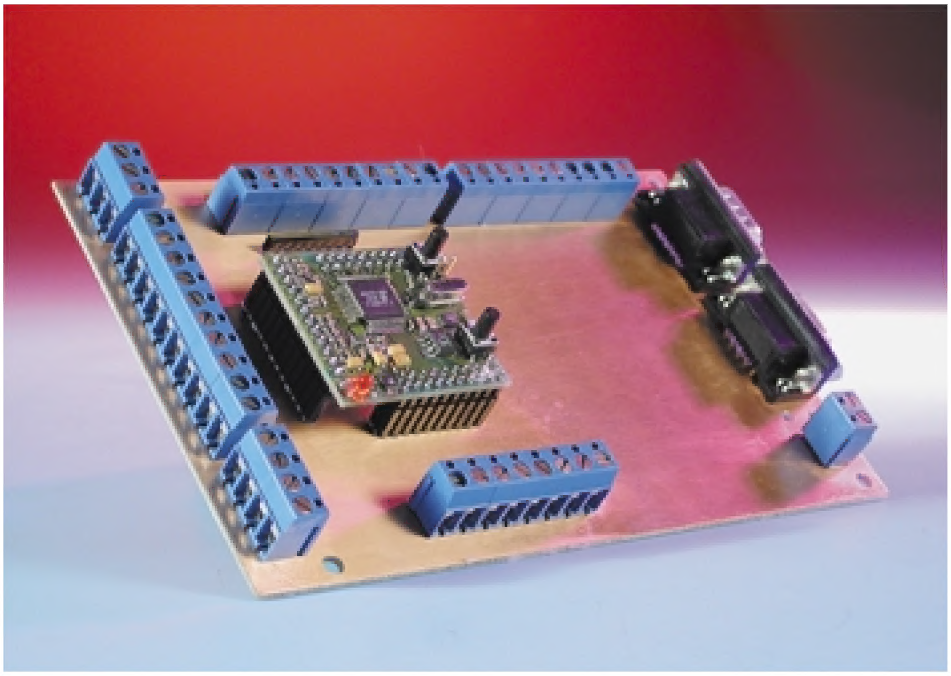


Figure 3. The prototyping motherboard with ISAC cube fitted.

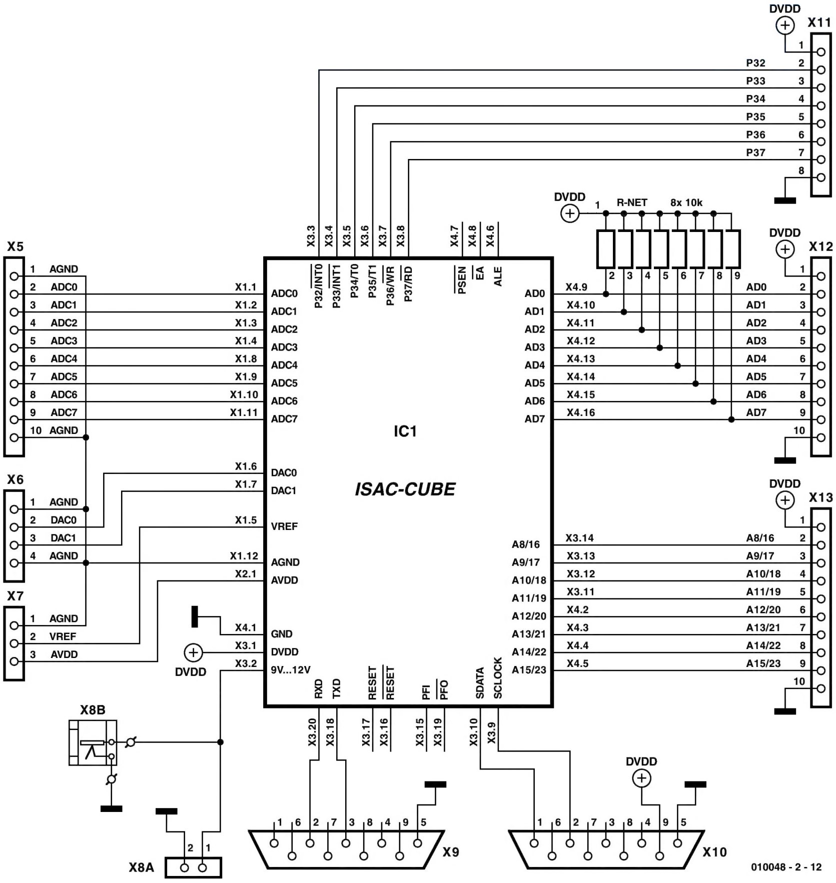


Figure 4. Circuit diagram of the simple prototyping motherboard.

COMPONENTS LIST
(simplest version)

Resistors:

R-Net = 8-way 10kΩ SIL array

Miscellaneous:

X5,X6,X7,X8A,X11,X12,X13 = PCB screw terminal block, 47-way, one row, lead pitch 5mm

X9 = Sub-D plug (male), 9-way, angled pins, PCB mount

X10 = Sub-D socket (female), 9-way, angled pins, PCB mount

X8 = jack socket, 3.5 mm, mono, PCB mount

15-way SIL pinheader

36-way pinheader (double row)

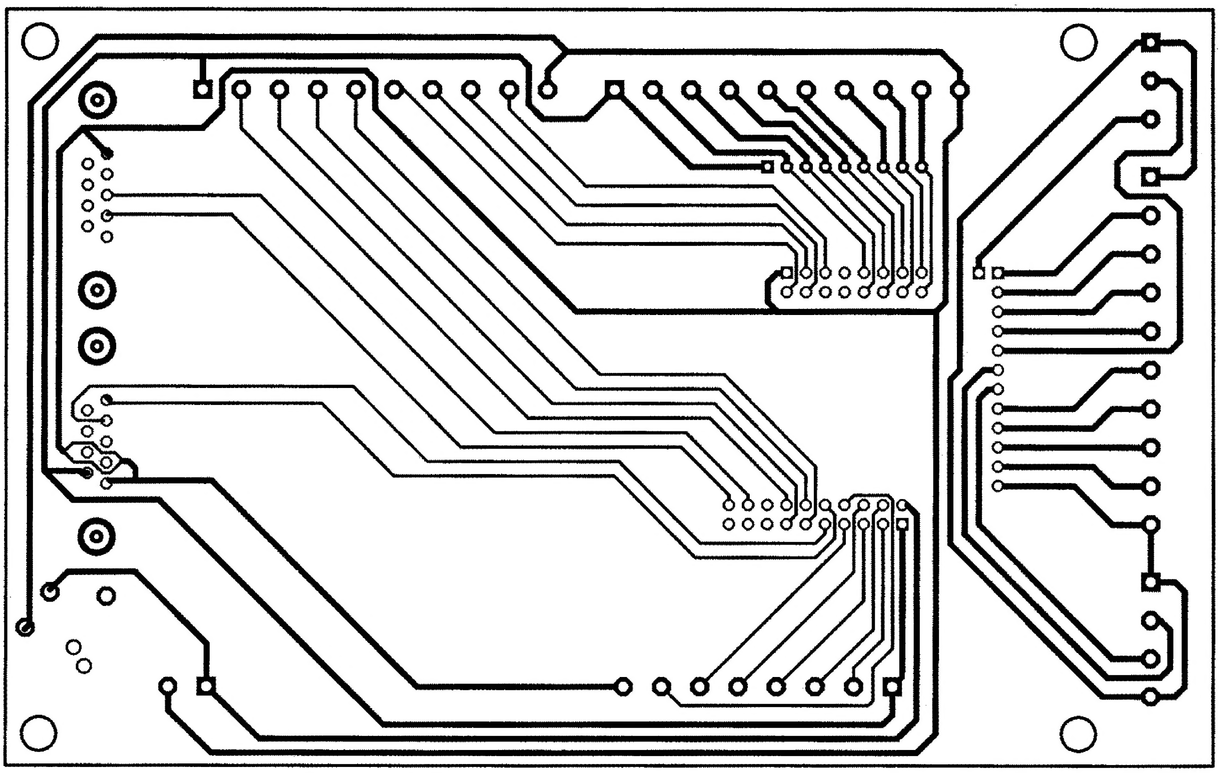
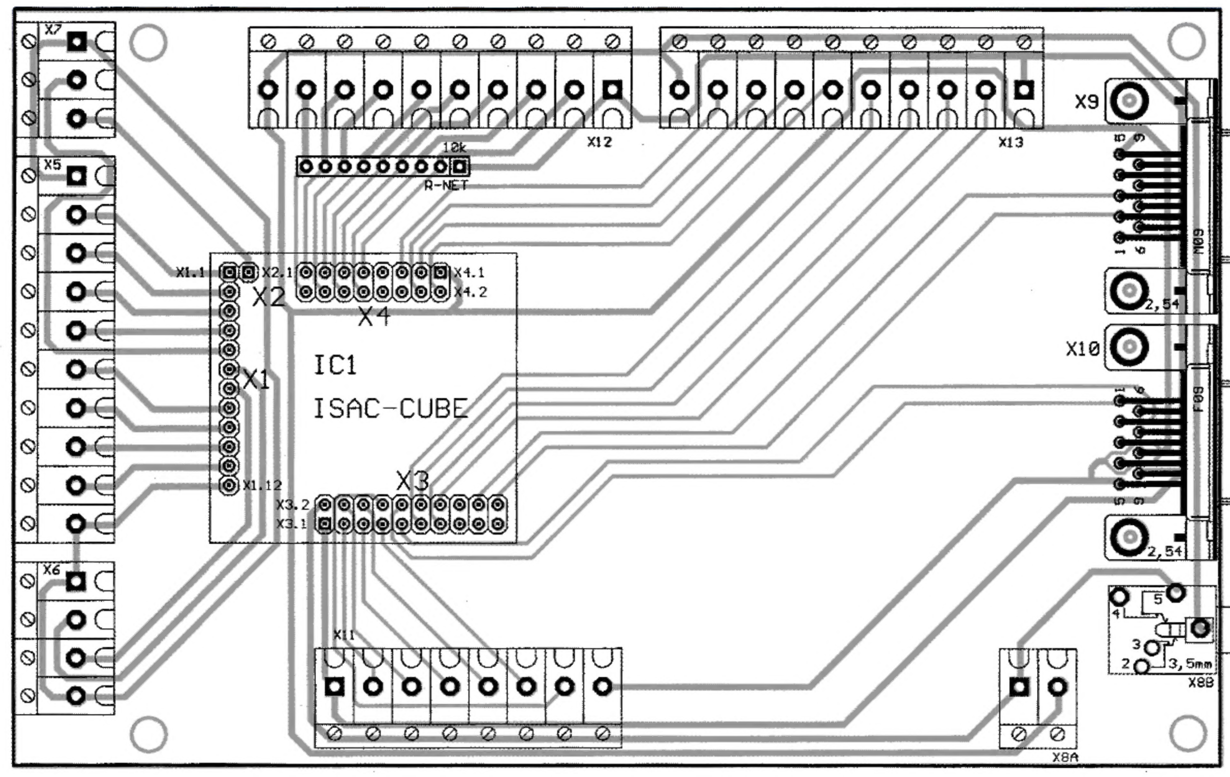


Figure 5. Layout of the prototyping motherboard.



message from the ADuC812 should appear on the PC's monitor. This switch-on message only appears when using a ready-built cube, in which the ADuC812 has already been programmed with a small amount of code. If you build your own cube, the ADuC812 is initially blank and must have a suitable program downloaded into it.

You can use any terminal emulation program to receive these communications on the PC, such as the HyperTerminal program that is provided free with Windows. In any case, the required communications settings are: 9600 baud, 8 data bits, no parity, 1 stop bit and no handshake.

We have now described all the hardware required to use the ADuC812. In the next instalment of this series we will discuss the software development environment and write our first program.

(010048-2)

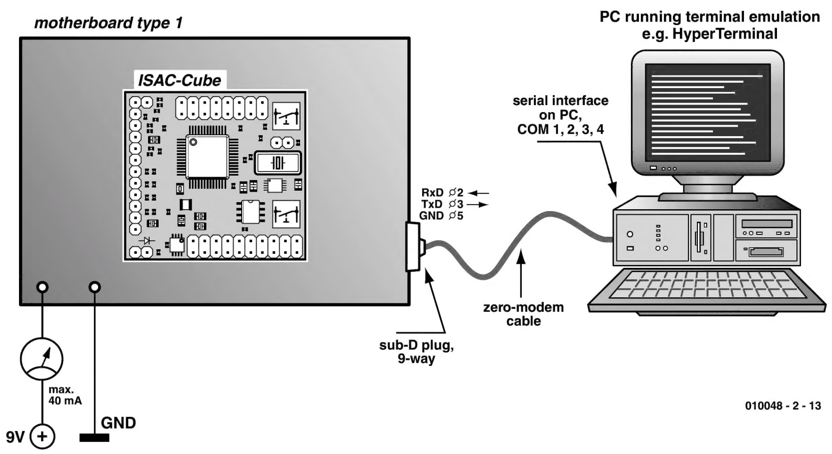


Figure 6. Connecting the ISAC cube for its first test.

Website references:

[1] MicroConverters on the Internet:
www.analog.com/microconverter

[2] Analog Devices on the Internet:
www.analog.com

Suggested source for components:

PalmTec - Mikrocontroller-Lernsysteme
Att. Prof. Dr. B. vom Berg
Mintarder Weg 27
D-45219 Essen
Germany
Tel.: (+49) 2054 84884
Internet: www.palmtec.de